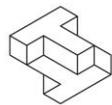


Chemicals of Innovation

Teacher Resource Guide



The Tech
Museum of Innovation

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How to use this Document

The resources provided in this document are not required to be used in preparation for your lab. They are simply resources that we thought might be helpful to you and engaging for your students in preparation for your lab. It is your choice to use them, you may pick as few or as many to implement as you like.

**If you are receiving a Title 1 scholarship for your lab, you are required to implement a vocabulary or journal activity prior to your lab visit.*

Lab Summary

Investigate chemical properties and bring the periodic table to life as students experiment with endothermic and exothermic chemical reactions and explore real-life applications and innovations featuring the elements of life.

Grade Levels: 5-8

Student Outcomes:

- 1) Students will be able to identify the name, atomic number, and atomic symbol of elements on the periodic table.
- 2) Students will be able to describe the difference between physical and chemical (endothermic and exothermic) reactions.
- 3) Students will be able to utilize the scientific method to carry out experiments with chemical reactions.

State and National Standards Connections:

Next Generation Science Standards

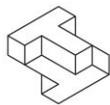
- Grade 5: *Physical Sciences:* 5-PS1-2, 5-PS1-3, 5-PS1-4
- Grade 6-8: *Physical Sciences:* MS-PS1-2

Common Core Language Arts Standards-*Speaking and Listening*

- Grade 5: SL.5.1.b-d; SL.5.4
- Grade 6: SL.6.1.b-d
- Grade 7: SL.7.1.b-d
- Grade 8: SL.8.1.b-d

California Science Content

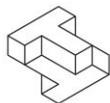
- Grade 5: *Physical Sciences:* 1.a-d, f; *Investigation and Experimentation:* 6.a-f, h
- Grade 6: *Investigation and Experimentation:* 7.a,b,d,e
- Grade 7: *Investigation and Experimentation:* 7.a,c,e
- Grade 8: *Physical Sciences:* 3.a-b, 3.f, 5.a-c, 7.a-c; *Investigation and Experimentation:* 9.a-Related Texts



Related Links and Games

The following links and games provide additional information on chemical reactions, the periodic table, and chemistry experiments that can be done from home or in the classroom. We are not endorsing the following organizations, but feel that the information provided by said organizations may be of benefit to your students and may help enhance the learning experience of the lab.

- *Fireworks and Elements:* At this site, you and your class can investigate the components of fireworks and how the many elements of the periodic table help to create the visual spectacle of fireworks.
<http://www.pbs.org/wgbh/nova/physics/periodic-table.html>
- *Chemiluminescence:* This American Chemical Society site offers demonstrations, simple activities, articles, and videos about chemiluminescence-the emission of light through a chemical reaction. Most of the activities are possible with inexpensive materials or materials that can be found in the home or classroom.
<https://www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/lightsticks-and-luminescence.html>
- *Chemistry Experiments:* This American Chemical Society site has simple easy to do experiments for in the classroom or back at home. It also includes fun science facts about everyday objects and interactive games for students. <http://www.acs.org/content/acs/en/education/whatischemistry/adventures-in-chemistry/experiments.html>
- *From Sand to Silicon - the Making of a Chip:* This resource from Intel Newsroom has videos and graphics explaining the process of making microchips from silicon. <http://newsroom.intel.com/docs/DOC-2476>
- *The pH Scale:* This BrainPOP Movie explains the pH Scale, why an acid is an acid, and a base is a base. BrainPOP account required for this. <https://www.brainpop.com/science/matterandchemistry/phscale/>
- Students can also do a free virtual lab with BrainPOP to learn how to calibrate a pH meter and use it to measure the acidity of standard solutions (Adobe Flash Player needs to be installed).
<https://www.brainpop.com/games/virtuallabsphscaleandmetercalibration/>
- *Kitchen Chemistry:* On this PBS Kids site students explore a virtual kitchen and perform online experiments to solve a puzzle and get a reward (Adobe Flash Player needs to be installed).
<http://pbskids.org/zoom/games/kitchenchemistry/index.html>



Related Texts

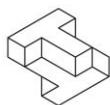
The following titles may provide students with a greater contextual understanding of the field of chemistry. Included in the list are narratives (fiction/nonfiction), referential texts, and books that extend learning beyond the scope of the lab. We are not endorsing the following authors, but feel that the information provided by said authors may be of benefit to your students and may help enhance the learning experience of the lab.

Narratives

- The Mystery of the Periodic Table. By Benjamin D. Wiker.
 - Recommended for grades 4-8
 - A delightful and absorbing journey through the creation of the periodic table and the discovery of the elements. The book is progressively challenging with the final chapters best suited for ages 12-13 or for guided reading.
- Adventures of the Elements (Volume 1). By Richard E James III
 - Recommended for grades 4-8
 - A book about five siblings who discover a box that contains the ability to see the strange, invisible creatures that wage wars and create substances that control everything we, as humans, see and do. It is a quest through a chemical world alongside “element guardians” to save the world from diabolical molecules like Ozzie Ozone and Dert Phosphate.

References

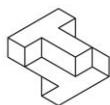
- How to Make a Universe with 92 Ingredients: An Electrifying Guide to the Elements. By Adrian Dingle.
 - Recommended for grades 5-8
 - An imaginative way for young readers to connect chemistry with the science of their daily lives. The book begins with the building blocks of the universe – atoms, subatomic particles, elements, and compounds – and is filled with browsable pages on a multitude of everyday topics – from stars to soap – and their relation to chemistry.
- The Cartoon Guide to Chemistry. By Larry Gonick and Craig Criddle.
 - Recommended for grades 7-12
 - This book covers the basics of the history of chemistry, atomic structure and the periodic table, bonds, reactions, energy, matter, etc. in a humorous way.
- Scholastic Discover More: The Elements. By Dan Green.
 - Recommended for grades 5-9
 - An in depth book that explains the forces that create elements and their impact on our daily lives. Best utilized as a quick reference for interesting facts, figures, and images on the more than 90 elements that make up our universe.
- Why Chemistry Matters Series. By Lynnette Brent.
 - Recommended for grades 3-8
 - A series of books that covers many different aspects of chemistry including Chemical Changes, Elements and compounds, Mixtures and Solutions, and the States of Matter.
- Basher Science: Chemistry: Getting a Big Reaction! By Dan Green.
 - Recommended for grades 4-12
 - “Imagine chemistry as a community of dynamic characters, each with its own personality. This book is your essential guide to the explosive guys who interact, combine, and change to make up everything around us.” (www.basherbooks.com) An imaginative introduction to the many aspects of chemistry.



- Basher Science: The Complete Periodic Table: More Elements with Style! By Dan Green.
 - Recommended for grades 4-12
 - “Do you confuse boron with barium and chlorine with fluorine? Fear not! This book comes to the rescue by mixing science and art to create the most unique periodic table you’ve seen.” (www.basherbooks.com) An imaginative introduction to the periodic table.

Extensions

- The Disappearing Spoon: And Other True Tales of Madness, Love, and the History of the World from the Periodic Table of Elements. By Sam Kean.
 - Recommended for grades 7-12
 - The periodic table is more than just a scientific achievement; it is a catalogue of stories about adventure, betrayal, and obsession. This book investigates these tales element by element, following the history of the (frequently) mad scientists who discovered them. Easily select the most interesting chapters/stories or read the whole thing.
- Stuff Matters: Exploring the Marvelous Materials that Shape our Man-Made World. By Mark Miodownik.
 - Recommended for grades 7-12
 - An accessible and witty book on material science. Easily select the most interesting chapters or read the whole thing.
- Napoleon’s Buttons: How 17 Molecules Changed History. By Penny Le Couteur and Jay Burreson.
 - Recommended for grades 7-12
 - Seventeen groups of molecules are traced as the most influential molecules in history. Investigating how molecules have been the catalysts for change and how the position of an atom can create enormous historical shifts, the book is a captivating way to study the elements. Easily select the most interesting chapters or read the whole thing.
- The Periodic Table. By Primo Levi.
 - Recommended for grades 10-12
 - A collection of short stories by Primo Levi, each named after an element on the periodic table. The stories are autobiographical episodes of the author’s experiences as a Jewish-Italian doctoral-level chemist during WWII. Easily select the most interesting stories or read the whole thing.



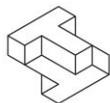
Gallery and Exhibit Connections

Body Worlds Decoded Gallery (Upper Level)

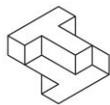
- *Body Worlds Decoded*: Students use augmented reality and other emerging technologies to examine organs and body systems through immersive 3D models.
 - Connection to the lab:
 - Students can view bodies preserved through plastination, a process which begins with an acetone bath to remove water and body fats, followed by the impregnation of a silicon polymer into all the cells of the body, and ends with the specimen being hardened by gas, light or heat.
 - Activities to complete at the exhibit:
 - Use our custom AR system, Iris, to view and interact with 3D models of the body.
 - Students can view the chemical signals of neurons, X-ray and SEM (Scanning Electron Microscope) images of internal organs and external influences on the human body (pollen grains), none of which would have been possible without Chemistry.
 - Students will also use Iris to view kidney stones, which are made of mineral and salt deposits.
 - Questions to guide student learning:
 - How do you think chemistry might be involved in the process of developing specimens for Body Worlds?
 - *Plastination is a process in which the cells of a cadaver are impregnated with a flexible polymer, preserving the body and the internal organs and systems indefinitely.*
 - Has anyone ever heard of acetone? What are some of the common uses of acetone?
 - *Nail polish remover; paint thinner*
 - *Acetone is a chemical solvent that dissolves grease (fats) and other chemical compounds such as paint and plastics (polymers).*
 - *After being treated with formaldehyde to kill bacteria, the cadaver is submerged into an acetone bath to remove all the water and fats. Acetone replaces the water within the cells so that they maintain their physical structure and shape.*
 - What type of plastics do they use for the plastination process?
 - *Polymers – large molecules that consist of repeating chains of similar chemical units. Polymers are both natural and synthetic, the latter consisting of plastics, resins, rubber, and many others.*
 - Apart from plastination, how has Chemistry influenced advances in medical technology that we see in Body Worlds?
 - *Without the discovery of atoms or electrons, we would not been able to get images from inside the human body using X-rays.*
 - *A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The most common SEM mode is detection of secondary electrons emitted by atoms excited by the electron beam.*

Biodesign Studio (Upper Level)

- *Bio Inks*: A drop-in activity where students can harvest, tinker and create art with a natural bio-pigment produced by living bacteria. Dates and times vary; please check the schedule when you arrive.
 - Connection to the lab:
 - The pigment that extracted from the bacteria to make the bio ink is pH sensitive. Students can experiment with the different acids and bases to make different colors of ink.



- Activities to complete at the exhibit:
 - Perform the activity presented in the BioTinkering Lab – all guidance is done by a Gallery Facilitator.
- Questions to guide student learning:
 - Your second test tube in the activity is a control. What is a control, and why do you need it in science?
 - What color(s) bio ink did you make? Did you add an acid or base to make this color?
 - Do you think it is better to make inks from natural sources, rather than synthetically produce them?
- **Living Colors Lab:** Do a guided lab experiment using real tools and reagents to engineer bacteria for the purpose of finding new living colors.
 - Connection to the lab:
 - *Chemical Transformation of Bacteria* - The exhibit uses a common lab biology protocol for introducing foreign DNA into bacterial cells called **chemical transformation**. The basic steps are:
 - Visitors get a blue tubes of bacteria that contain billions of *E.coli* cells.
 - Visitors get a red tubes that contains DNA suspended in a 100mM CaCl_2 solution.
 - Visitor mix the contents of the 2 tubes together.
 - They then give the mixture a short “heat shock” at 42°C.
 - Normally large, negatively charged molecules like DNA can’t pass through the lipid bilayer of a cell membrane. Together, the above steps cause the bacterial cell membranes to become more permeable, allowing the DNA inside. The positive Ca^{2+} ions from CaCl_2 are thought to assist in making “holes” in the membrane and binding the negatively charged DNA to the cell membrane, which help get it through the hydrophobic center of the lipid bilayer.
 - *The Chemistry of Fluorescent Proteins* - The DNA used in the exhibit has 3 genes in it that code for 3 different fluorescent proteins: a red one (called mApple), a green one (called sfEmerald), and a blue one (called mBlueberry). The excitation and emission wavelength for each are listed below:
 - mApple: excitation wavelength = 568 nm, emission wavelength = 592 nm
 - sfEmerald: excitation wavelength = 487 nm, emission wavelength = 509 nm
 - mBlueberry: excitation wavelength = 402 nm, emission wavelength = 567 nm
 - Fluorescence occurs when a photon of light collides with a molecule that is a fluorophore (such as the three fluorescent proteins listed above). This collision causes the molecule to gain energy and an electron is excited from its initial ground state to a higher energy state. After a few microseconds and after having lost some of the gained energy, the electron falls all the way back down to its ground state. With this fall, the electron emits a photon of light with the same energy as the difference between the excited and ground states. Because of the partial loss of energy before the final fall, the energy of absorbed and emitted photons differ, changing the color of the emitted light. For example, green fluorescent protein (GFP) absorbs blue light and emits green light.
 - Activities to complete at the exhibit:
 - Perform the activity presented in the Living Colors Lab – all guidance is done through the computer program, Gallery Facilitators are on hand for questions and assistance.
 - Questions to guide student learning:
 - What is the chemical name for CaCl_2 ? Where else did you use it today?
 - Give one example of how you can excite electrons, and what you will observe because of it.
 - What was the most common color you found in your analyzed dish? What was the most unique color you found?
 - Bonus:
 - A local high school class that does science parody videos did one about fluorescence which we helped them film in Biodesign Studio: <https://www.youtube.com/watch?v=y-J5Le0o7Dk>.



Writing Prompts

The following writing prompts and questions are just a few examples of journal topics to incorporate writing into your students' lab experience. If you feel that one of the below prompts does not meet your needs, you are welcome to use your own, but please make sure it is related to the chosen lab experience. If you have a related writing prompt you would like to share with The Tech and other teachers, please let us know on our teacher survey that will be available in the lab.

Most of the writing topics could be used as either pre-lab or post-lab writing. You may choose the prompts that work best for your class and schedule.

Pre-Visit Writing Topics/Prompts

Generic

- We will be attending ___*lab name*___ at The Tech Museum of Innovation; what do you think we will learn about in the lab? What do you want to know about this topic? What do you already know about this topic?
- We will be attending ___*lab name*___ at The Tech Museum of Innovation; what are you looking most forward to in this lab? Why?

Specific to Chemicals of Innovation

- There is more to chemistry than just mixing solutions together. What does chemistry mean to you? Why?
- (If you have already reviewed the Periodic Table) Everything in our world is made of different combinations of the elements on the Periodic Table. What is your favorite element on the Periodic Table and why? What would you do if this element hadn't been discovered?
- Safety is very important in a chemistry lab. What would be your top three chemistry lab safety rules and why?

Post-Visit Writing Topics/Prompts

Generic

- We learned a lot in our ___*lab name*___ lab. What were your two favorite things you learned in the lab? Why?
- The principal is excited to hear all about your lab experience. Explain what you did and learned about in the lab since she or he was unable to attend the lab.

Specific to Chemicals of Innovation

- Imagine you are a chemical engineer. You are creating a new product that features either an endothermic reaction or an exothermic reaction. What is your product, what type of reaction does it feature? Create an advertisement for your product, complete with a drawing, simple and brief explanation of the purpose of your product, and a persuasive argument for why everyone should buy your product.
- The principal wants to hear all about your favorite chemical reaction from the lab. Explain which reaction was your favorite and why. Then describe the reaction so the principal can understand why you liked it so much.
- Describe the difference between a chemical reaction and a physical reaction. Provide an example of each type of reaction.



Pre-Visit Vocabulary

These are words and concepts that we will discuss in the lab. Your students' experience will be enhanced if they are familiar with these terms prior to your visit. Below you will find several graphic organizers and games to aid in your vocabulary review.

Terms and Definitions

- **Atom:** the smallest component of an element having the chemical properties of the element
- **Atomic Number:** the number of protons in the nucleus of an atom for a particular element. **Compound:** two or more elements bonded together whose composition is constant
- **Chemical Reaction:** a process that leads to the irreversible transformation of one set of chemical substances (reactants) to another (product).
- **Compound:** two or more elements bonded together whose composition is constant
- **Control:** a standard of comparison in scientific experimentation
- **Electron:** an elementary particle having a negative charge, found outside the nucleus of an atom
- **Element:** a substance comprised of identical atoms that cannot be separated into simpler substances by chemical means
- **Hypothesis:** educated guess about what we think will happen
- **Neutron:** an elementary particle having no charge, found in the nuclei of all atoms except those of hydrogen
- **Nucleus:** the positively charged central region of an atom, composed of protons and neutrons and containing almost all of the mass of the atom
- **Products:** chemical compounds that are a result of a chemical reaction
- **Proton:** an elementary particle having a positive charge that is a fundamental constituent of all atomic nuclei
- **Reactants:** chemical compounds that are initially mixed to create a chemical reaction.
- **Solution:** a homogenous mixture that is composed of only one phase of matter (i.e. a powder that has been completely dissolved into a liquid).

Advanced Vocabulary – these terms may come up in your lab depending in time constraints

- **Catalyst:** something that accelerates the rate of a chemical reaction which itself remains unchanged by the reaction
- **Hygroscopic:** a compound that is able to absorb water from the atmosphere.
- **Polymer:** a large molecule that is made up of many repeating sub-units.

Vocabulary Activities:

Graphic Organizers

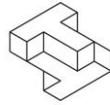
- **Frayer Graphic Organizer:** The Frayer Graphic Organizer is a great tool for vocabulary development. This graphic organizer allows students to write their own definitions, define characteristics, and provide examples and non-examples. This tool will lead your students to a deeper understanding of the vocabulary and how it relates to their lives. On page 10 you will find a blank Frayer Graphic Organizer for your use in the classroom.
 - For more information on the Frayer Model and how to implement it, please visit the following link:
<http://www.theteachertoolkit.com/index.php/tool/frayer-model>
- **Vocabulary Graphic Organizer:** This graphic organizer is a great tool for younger students as well as English Language Learners. Although very similar to the Frayer Model, this graphic organizer includes a drawing of the vocabulary term and the use in a sentence. On page 11 you will find a blank Vocabulary Graphic Organizer for your use in the classroom.



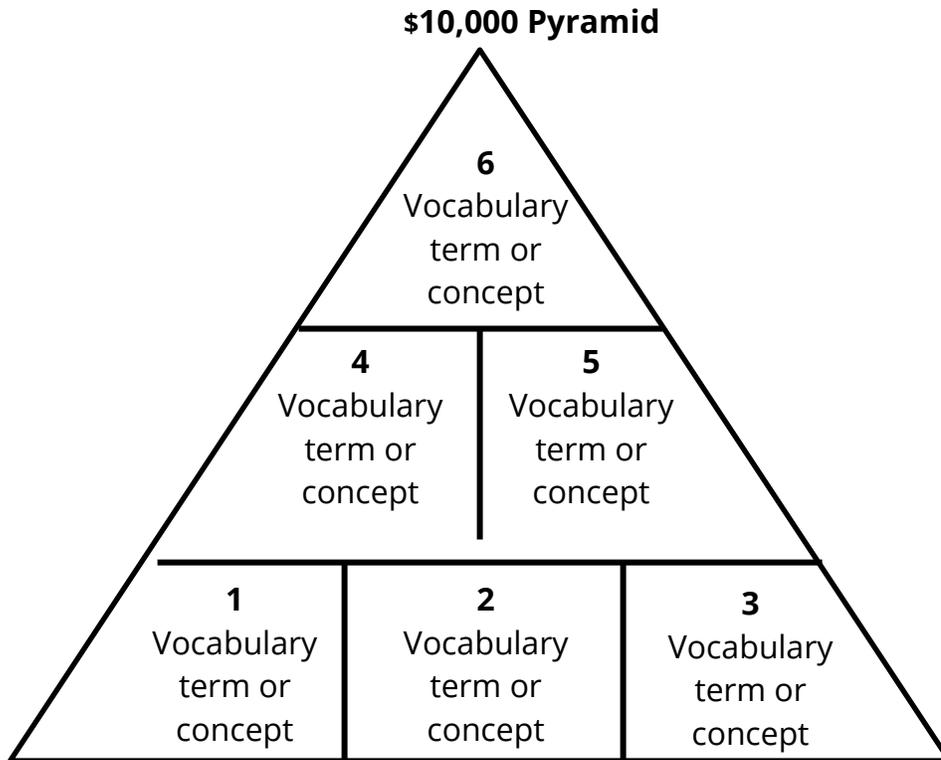
- **Circle Map:** This graphic organizer is a great tool for helping all students develop an overall sense of a topic. It is also very helpful for beginning and early intermediate English Language Learners. This graphic organizer lets students brainstorm what a term or concept means to them and provides a frame of reference for the term. On page 12 you will find a blank Circle Map for your use in the classroom.
 - For more information on the Circle Map and other Thinking Maps, please visit the following link:
 - <http://thinkingmaps.com/why-thinking-maps-2/>

Vocabulary Review Games

- **Quiz, Quiz, Trade:** This is a fun cooperative game for students to review vocabulary terms. For more details and to see an example of Quiz Quiz Trade in action, please visit the following link:
<http://www.theteachertoolkit.com/index.php/tool/quiz-quiz-trade>
 1. Create questions or vocabulary cards. On one side of an index card, write the question or vocabulary term; on the other, the answer or definition. Pass out the cards to students. If there are not enough terms for everyone to have a different card, try using different “back” sides to the same cards (e.g. instead of the definition again, have a drawing, a question about the term, characteristics of the term, or an example of the term).
 2. Pair up. When all cards have been passed out, students find a partner to quiz with their card.
 3. Hands up. When both partners have completed the quizzes correctly, they put their hand up to show other students that they are ready for a new partner to quiz.
- **Back-words:** This game is part Charades part 20 Questions. In this review game, students have to guess the vocabulary term that is on their back by asking questions of a partner or having the partner act out the term.
 1. Write your vocabulary terms on index cards. If there aren't enough terms for each student to have a different one, you can make two sets and divide the class into two groups. You may also add in other related vocabulary terms that you have been studying in class.
 2. Tape one term onto the back of each student so that he or she cannot see the word.
 3. Have students pair up. Each partner should look at the word on their partner's back. Partners take turns asking questions or acting out or gesturing about the term that is on their back. (e.g. “Am I an element? Am I part of an atom? Do I make up all matter? Etc.) Partners must ask at least 2 questions before guessing their word.
 4. When both partners have correctly guessed their word, they put a hand up to signal that they are in need of a new partner. Continue game play until everyone has guessed their word.
- **\$10,000 Pyramid:** This review game is exactly like the classic game show. Students will work in pairs, taking turns to describe the words and to guess the words.
 1. Break up the terms into two groups. Each partner will take on one group of words.
 2. Have each partner fill out the worksheet on the next page with their group of words.
 3. For the first round, Partner A will be the one describing the term and Partner B will be the one guessing the term. Partner A will describe the term (starting with 1) using the words he or she wrote down on the worksheet. From the description, Partner B will guess what the term is.
 4. When Partner B guesses the word correctly, Partner A moves on to the next word.
 5. When Partner B correctly guesses all the words in Partner A's pyramid, they switch places and Partner B will describe the terms on his or her pyramid while Partner A guesses the terms.
 6. You can time this activity like on the quiz show, but it may intimidate some students



Student Name: _____



Write descriptive clues about each vocabulary term or concept

1. _____

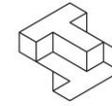
2. _____

3. _____

4. _____

5. _____

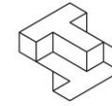
6. _____



Frayer Graphic Organizer

Definition	Characteristics
Examples	Non-Examples

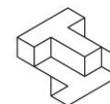
Vocabulary Word



Vocabulary Graphic Organizer

Definition	Characteristics
Sentence	Drawing

Vocabulary Word



Circle Map

